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MICROFOSSILS FROM THE FLECHADO FORMATION (PENNSYLVANIAN, DESMOINESIAN) NEAR TALPA, NEW MEXICO

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Abstract—The Flechado Formation near Taos, New Mexico contains a marine microfauna with many elements previously unreported from New Mexico. This microfauna includes 14 species of foraminifers, 15 species of ostracods, spirorbid worm tubes, as well as parts of holothurians, ophiuroids, echinoids, a micro-crinoid and several vertebrate ichthyoliths. The fauna is consistent with the Desmoinesian age as determined from other fossil evidence. The environment is thought to be nearshore, normal marine possibly with a macroalgae flora as evidenced by large numbers of attached organisms without obvious attachment sites preserved.

INTRODUCTION

Studies of New Mexico Pennsylvanian microfossils, excepting the Fusulinidae, have been sparse. The most comprehensive study was that of Toomey (1980) on a lateral equivalent of the Flechado, the La Posada Formation, near Las Vegas, New Mexico. Other comprehensive work on Pennsylvanian microfossils of New Mexico include Werrall (1961) in an unpublished master's thesis and Toomey et al. (1977) on a late Pennsylvanian reef from the Sacramento Mountains of south-central New Mexico. Sohn (1972) described a new genus and species of ostracod from the Pennsylvanian of New Mexico. All other known studies consist either of lists of taxa (e.g., Kelley and Northrop, 1975) or abstracts (e.g., Kietzke, 1983) lacking illustrations and detailed documentation.

The richly fossiliferous Pennsylvanian localities near Talpa, New Mexico (Fig. 1; Table 1) have been known to paleontologists for years because of their abundant and diversified mollusc and brachiopod faunas. Kues (1984, 1990) reviewed the general paleontology and illustrated the gastropod and bivalve taxa. These collections were made by Dr.

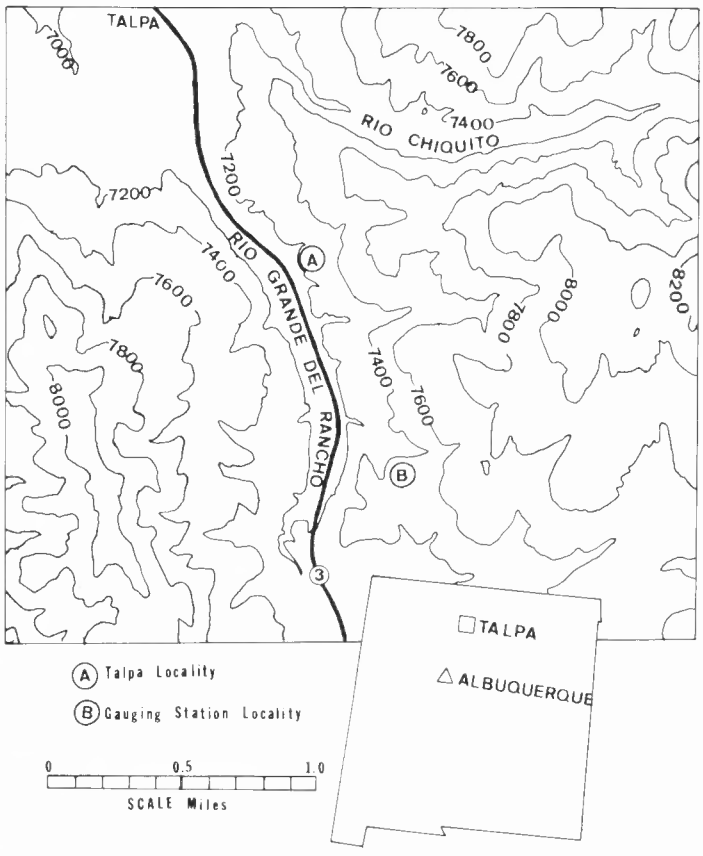


FIGURE 1. Locality map for the Talpa and gauging station localities, Taos County, New Mexico.

TABLE 1. Occurrences of microfossils in the Flechado Formation samples from Talpa (units 3, 5, 7) and the gauging station (unit R).

TAXON	UNIT B5	B7	C3(BASE)	C3(TOP)	R
FORAMS					
Hemisphaerammina sp.	0	0	0	0	1
Ammodiscella sp.	0	1	5	3	10
Lituotuba delicatula	0	1	1	11	71
Glomospira sp.	0	0	2	2	10
Ammovertella sp.	0	1	0	5	0
Climacammina antigua	85	0	8	34	3
?Placopsilina ciscoensis	0	0	0	1	2
?Endothyranella sp.	0	0	0	1	0
Tubertina sp.	0	0	0	0	1
Globovalvulina bulloides	1	4	0	0	0
Endothyra tortilis	13	5	9	5	0
Glyphost. holdenvillensis	12	0	5	7	1
Tetrataxis conica	4	1	0	13	0
Tetrataxis corona	6	0	0	3	4
?Pseudostaffella sp.	0	0	2	0	0
fusulinids	213	27	41	40	3
SUM	334	40	73	125	106
SPIRORBIDAE					
Spirorbis sp.	0	1	0	0	0
Spirorbis sp. B	1	0	0	0	0
ECHINODERMS					
CRINOIDEA					
stem fragments	112	0	0	0	0
ambulacra	52	0	0	0	0
Kallimorphocrinus sp.	0	0	0	0	1
HOLOTHURIANS					
Tetravirga sp.	12	2	0	0	0
Eocaudina gutschicki	23	0	0	0	0
Achistrum sp. A	0	1	0	0	0
Achistrum sp. cf A. gamma	7	0	0	0	0
Thalatocanthus consonus	3	0	0	0	0
Protocaudina kansasensis	15	15	0	0	0
SUM	60	18	0	0	0
ECHINOIDS					
Echin. type C brace	12	1	0	0	0
Echin. type B pyramid	8	0	0	0	0
Echin. type F epiphyses	2	0	0	0	0
Echin. type D spine	33	0	0	0	1
Echin. type A pedicullaria	7	0	0	0	0
Echin. type E ambul. plate	55	0	0	0	20
OPHIURIANS					
Ophiur. type D ossicles	7	0	0	0	
Ophiur. type A vert ossicles	8	0	1	0	7
Ophiur. type B vert ossicles	21	0	0	0	3
Ophiur. type C vert ossicles	5	0	0	0	0
Ophiur. type I lateral shields	54	0	0	0	4
Ophiur. type E pedicullaria	3	0	0	0	0
Ophiur. type H tooth	0	1	0	0	0
Ophiur. type G spine	0	1	0	0	0
Ophiur. type H spine	1	0	0	0	
OSTRACODS					
H.sp.	5	0	0	2	4
K. inornata	0	0	0	0	6
K. fuldaensis	0	0	4	0	1
A. centronotus	0	0	1	0	7
R. simplicissimus	0	0	0	0	3
Youngiella sp.	3	0	0	0	0
C. inflata	11	0	5	4	0
B. grahamensis	12	0	3	20	10
O. oklahomensis	21	0	9	26	20
B. hoxbarensis	0	0	7	22	42
P. pediformis	0	11	0	0	3
C. rotunda	11	0	0	0	11
S. sulcata	7	7	9	8	7
Silenites sp.	0	0	0	2	0
Healdia sp.	1	1	0	0	1
SUM	71	19	38	84	115
PROBLOMATICA	11	0	0	0	0
VERTEBRATA					
Denticle type A	0	1	0	0	1
Scale type B	1	1	0	0	1
Tooth, Type C	2	2	0	0	0
Denticle type D	1	0	0	0	0
PYRITE CUBES	0	1	0	0	1

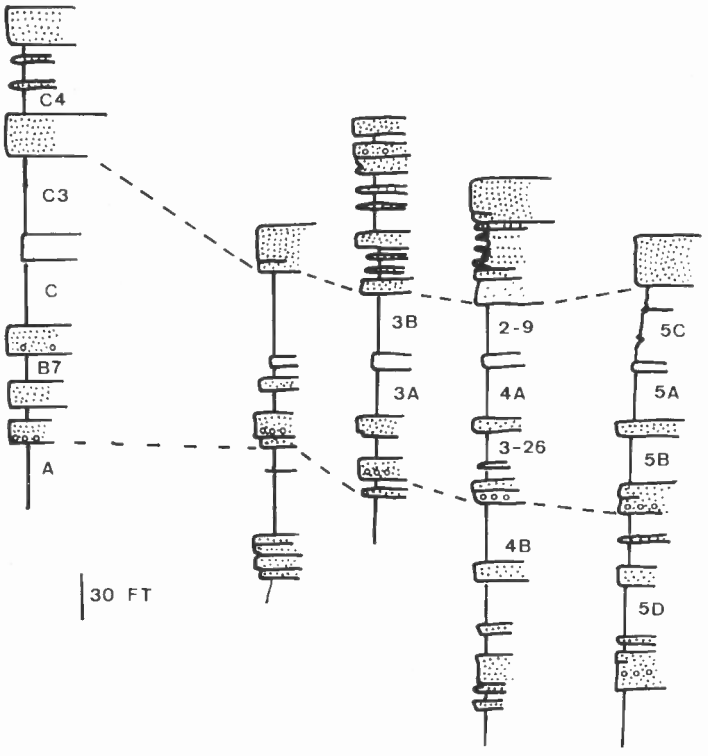


FIGURE 2. Stratigraphic sections of the Talpa and gauging station localities, locating the Kues sampling horizons.

Kues from slopes on the east side of New Mexico Highway 3 (Fig. 2) at two locations, one referred to as the Talpa locality, the other as the gauging station locality. Sutherland and Harlow (1973) studied brachiopods from near the Talpa locality, although they apparently never collected from the exact locality or intervals reported in this study. Miller et al. (1963) did measure a stratigraphic section just south of the Talpa locality from which Sutherland and Harlow reported the brachiopods. Casey (1981) studied the stratigraphy and depositional environments of the Flechado Formation in the Talpa area and included some paleontological and paleoenvironmental information.

SYSTEMATICS

The systematics of the microfossils described in this report are derived from several sources. The foraminiferal classification is that recently suggested by Loeblich and Tappan (1988). The Ostracoda classification is generally that of the *Treatise on Invertebrate Paleontology* (Benson et al., 1961); however, some aspects are from Sohn (1960, 1961).

Ophiuroid fragments are often common in marine microfossil samples, although complete specimens are extremely rare. The various skeletal elements, particularly the arm vertebrae and lateral shields, appear to have potential taxonomic value and in works on Mesozoic specimens have furnished the basis for systematic differentiation (e.g., Hess, 1962, 1963). Work on Paleozoic forms (e.g., Weller, 1930; Miller, 1958; Hattin, 1959; Mayou, 1969; Morris et al., 1973; Harper and Morris, 1978; Pabian and Strimple, 1973) has been more limited and generally restricted to more or less complete specimens. Thus, their biostratigraphic potential remains to be demonstrated. Paleozoic species cannot, at present, be identified based on isolated ossicles, and no attempt is made to do so in this paper. Echinoid and crinoid fragments are treated in a fashion similar to the ophiuroid fragments.

The holothurian sclerites follow the classification suggested by Frizzell and Exline (1966). Pawson (1966) suggested that holothurian sclerites be included in higher classifications used for modern holothurians, but Frizzell and Exline utilized no classification above family level. Considering the known variability of these structures and the possibility of confusion with sclerites from other echinoderm groups, this seems prudent and is the scheme followed in this report.

Vertebrate ichthyoliths have been placed in the Tway (1979) classification. Spirorbid worm tubes are described in a conventional systematic format.

Order Foraminifera Eichwald, 1830
Genus *Hemisphaerammina* Loeblich and Tappan, 1957
?Hemisphaerammina sp.
Fig. 3C

Description—Small, associated but not connected, hemispherical, smooth bumps attached to a fenestrate bryozoan fragment. Test round, about 60 microns across, leaving a very low lip on the attachment surface when removed.

Discussion—There is some question of whether this is indeed a Foraminifera or perhaps a pathogenic formation of unknown origin. The discovery of this organism on a single bryozoan fragment would make a more detailed analysis premature. The rim around the dislodged specimen would suggest attachment while the bryozoan was alive and able to secrete the rim.

Genus *Ammodiscella* Ireland, 1956
Ammodiscella sp.
Fig. 3A

Description—Test attached, consisting of tiny proloculus followed by a dextrally coiled tube of about uniform thickness; aperture open, at end of tube; wall smooth, siliceous, with a few scattered adherent grains.

Discussion—The rarity of this species precludes more detailed assignment at this time. Several species of this genus have been described based largely on acid residue specimens.

Genus *Lituotuba* Rhumbler, 1895
Lituotuba delicatula (Cushman and Waters, 1928)
Figs. 3O, 4F, 4K, 4R

Tolypammina delicatula Cushman and Waters, 1928, p. 62, pl. 8, fig. 3.

Tolypammina delicatula: Cushman and Waters, 1930, pp. 45–46, pl. 7, fig. 12.

Description—Proloculus small, surrounded by a coiled portion consisting of one to two coils, followed by a more or less straight, narrow tube very gradually increasing in diameter; all parts attached; aperture consisting of the open end of the tube; wall arenaceous with much cement, and few grains above fine silt size; wall thickness about 10 μm.

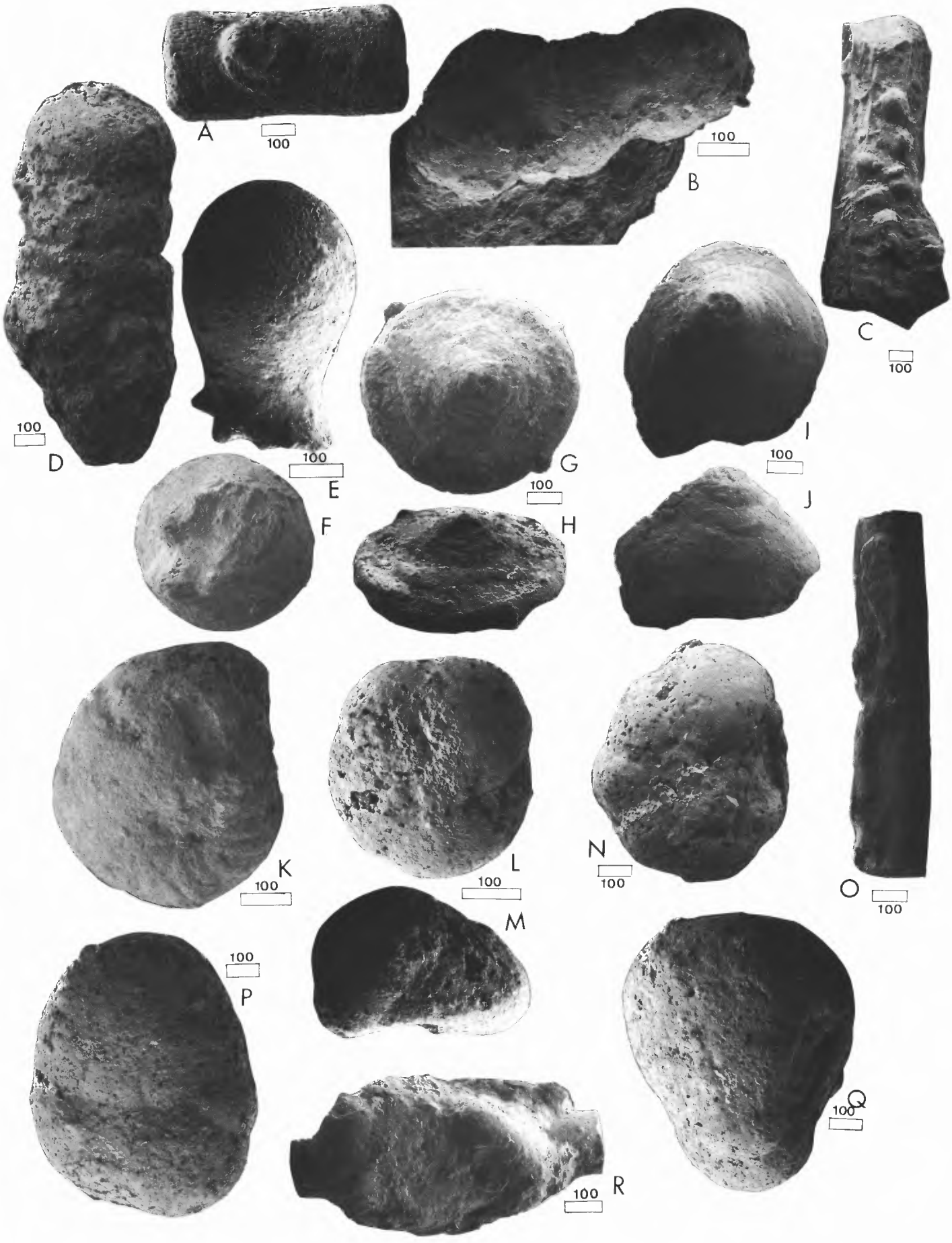
Discussion—This species is similar to *?Lituotuba filum* (Schmid) from the Permian Zechstein of Germany, differing primarily in having fewer coils in the coiled part of the test. There are a number of late Paleozoic species of *"Tolypammina"* that have a coiled early portion and should be placed in the genus *Lituotuba*.

Genus *Glomospira* Rzehak, 1885
Glomospira sp.

Description—Test unattached, roughly planispiral in early portion, later part irregularly coiled over early part; wall very finely agglutinated with much cement; tube increasing in size slowly during growth, aperture round, open, at end of tube.

Discussion—The irregularly coiled species of *Glomospira* are in need of systematic revision beyond the scope of this report.

FIGURE 3. Flechado Formation Foraminifera, scale bars in microns. A, *Ammodisoidella* sp. on crinoid fragment; B, *?Placopsilina* sp. top view; C, *?Hemisphaerammina* sp. on bryozoan fragment; D, *Climacammina antigua,* side view; F–G, *Tubertina bulbacea,* side view, attachment surface; H–I, *Tetrataxis corona,* top view, oblique side view; J–K, *Tetrataxis conica,* top and side views; L, *?Pseudostaffella* sp., side view; M–N, *Globivalvulina bulloides,* top and side views; O, *Endothyra tortilis,* side view; P–Q, *Glyphostomella holdenvillensis,* side and front views; R, *Litutuba delicatula* on a productoid spine.


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Genus *Ammovertella* Cushman, 1928
Ammovertella sp.
Figs. 3R, 4D–E

Description—Test attached, with a small proloculus followed by a tube that zigzags back and forth in increasingly longer loops; wall smooth with few distinct adherent particles, siliceous.

Discussion—A number of species of *Ammovertella* have been described, some based on specimens obtained from acid residues. The highly variable nature of this foraminiferan makes specific assignment impossible at this stage of study.

Genus *Climacammina* Brady, 1876
Climacammina antiqua (Brady), 1876
Fig. 3D

Textularia antiqua Brady, 1871, *in* Young and Armstrong, 1871.
Climacammina antiqua: Brady, 1876, p. 68, pl. 2, figs. 1–9.

Description—Test agglutinated, with a large amount of calcareous cement; incorporated material largely calcareous, up to 75 μm across; test consisting of a biserial initial stage consisting of five chambers past the proloculus, followed by a linear series of about three chambers; terminal chamber with a circular series of round openings about 80 μm across.

Discussion—Numerous species of this genus have been described based on cross section material. Because the Talpa specimens are isolated tests, comparisons with and between sectioned material was not attempted.

Genus *Placopsilina* D'Orbigny, 1850
?*Placopsilina ciscoensis* Cushman and Waters, 1930
Fig. 3B

Placopsilina ciscoensis Cushman and Waters, 1930, p. 74, pl. 12, figs. 7, 9.

Description—Test attached; proloculus followed by several nearly equal-sized chambers; attachment surface flat; wall agglutinated; aperture not observed.

Discussion—The Flechado specimens closely resemble the one described by Cushman and Waters. The Flechado specimen is not attached to a hard-bodied fossil and may have been attached to plant or chitinous material in life.

Genus *Globivalvulina* Schubert, 1920
Globivalvulina bulloides (Brady, 1876)
Fig. 3L–M

Valvulina bulloides Brady, 1876, p. 89, pl. 4, figs. 12–15.
Globivalvulina bulloides: Schubert, 1920, p. 153.
Globivalvulina bulloides: Plummer, 1948, p. 172, figs. 4, 5 [a detailed description and synonomy is found in this reference].

Description—Test consisting of small, usually internalized proloculus, followed by a series of about 4 biserially arranged, globular chambers; wall microgranular, calcareous; aperture an elongate narrow slit on underside of test at juncture of terminal and previous chamber.

Discussion—*Globivalvulina bulloides* is separable from *Globivalvulina biserialis* Cushman and Waters, 1930 by its smaller size and more globose chambers.

Genus *Tubertina* Galloway and Harlton, 1928
Tubertina bulbacea Galloway and Harlton, 1928
Fig. 3E–F

Tubertina bulbacea: Galloway and Harlton, 1928, p. 346.

Description—Test bulb-shaped, connected by short neck to roughly stellate attachment surface; surface covered with fine rounded reticulations on the end of the bulb, becoming smaller and fewer in number toward the neck; reticulations about 8 μm across; attachment surface irregularly flat, with small, stellate projections up to 20 μm long around it.

Discussion—*Tubertina bulbacea* differs from *T. plana* Reitlinger, 1950 in having a distinctly developed neck and hence a bulb-like shape. These same features separate it from *T. collosa* Reitlinger, 1950.

Genus *Endothyra* Phillips, 1846
Endothyra tortilis Jean, 1957
Figs. 3N, 4A–B

Endothyra tortilis Jean, 1957, pp. 27–28, pl. 1, figs. 4a–c, 5.
Endothyra kennethi Jean, 1957, pp. 28–29, pl. 1, figs. 6a–c, 7, 8a–c.

Description—Test asymmetrically planispiral, consisting of seven chambers in outer whorl; chambers inflated, final chamber with aperture a narrow slit along the base of the face; wall smooth and calcareous; SEM indicates numerous small square holes thought to result from the removal of diagenetically grown calcite crystals.

Discussion—Zeller (1950) placed the species of *Endothyra* that do not coil planispirally into the genus *Plectogyra*. I believe this feature to have subgeneric value at best and for now place this species in the genus *Endothyra*. This view is consistent with Loeblich and Tappan's (1988) revision of the foraminiferal genera. Jean (1957) separated *E. tortilis* from *E. kennethi* based on the amount of twist in the outer two whorls, the inflation of the chambers, the degree of sutural depression and the degree of apertural lip development. Examination of his figures, particularly figures 4 (*E. tortilis*) and 8 (*E. kennethi*), indicates these features are not consistently separable.

Genus *Endothyranella* Galloway and Harlton, 1930
?*Endothyranella* sp.

Description—Test small, preserved part consisting of only the linear part of the test with four even-sized, rounded chambers, terminal chamber slightly tapered with round aperture at end; wall calcareous, granular.

Discussion—The rare and fragmentary nature of this specimen makes comparisons impossible.

Genus *Glyphostomella* Cushman and Waters, 1928
Glyphostomella holdenvillensis (Harlton, 1927)
Fig. 3P–Q

Bradyina holdenvillensis Harlton, 1927, p. 18, pl. 2, fig. 1

Description—Test planispiral with four chambers in outer whorl; chambers highly inflated, approximately doubling in size at each chamber; apertures multiple, difficult to discern in SEM figures but consisting of narrow vertical slits in the lower face of the ultimate chamber; wall calcareous with many small square holes, similar to *Endothyra*.

Discussion—*Glyphostomella holdenvillensis* is most similar to *Glyphostomella triloculina* Cushman and Waters, 1928 from the Upper Pennsylvanian and may form an evolutionary continuum with that species. The major difference is the presence of four visible chambers in the present species and only three in *G. triloculina*.

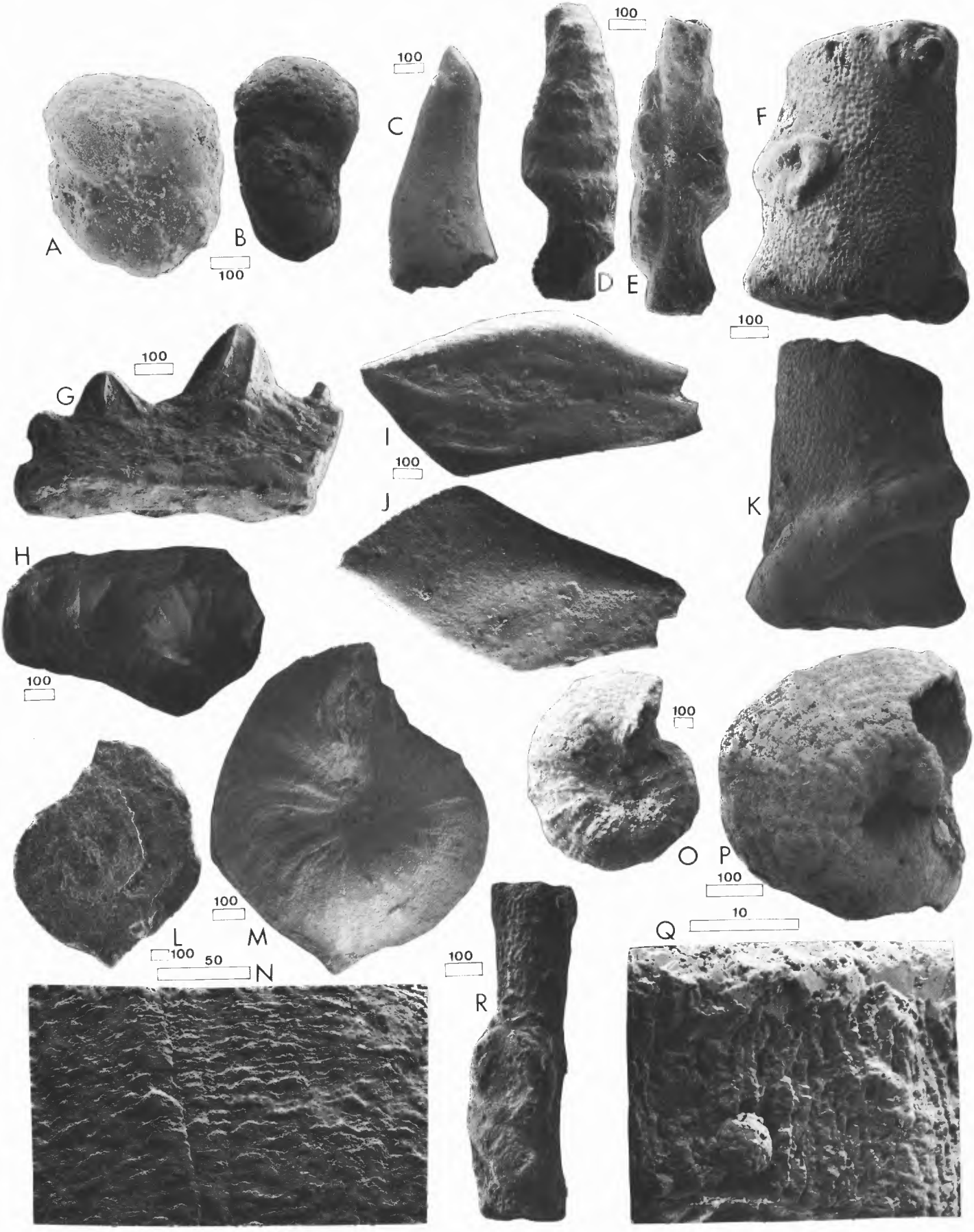
Genus *Tetrataxis* Ehrenberg, 1854
Tetrataxis conica Ehrenberg, 1843
Fig. 3I–J

Tetrataxis conica Ehrenberg, 1843, p. 106.

Description—Test free, cone-shaped, composed of three chambers in the outer whorl; ventral surface flat to slightly concave, with four radiating folds formed by the chambers over the apertures; wall calcareous, granular.

Discussion—The variety referred to as *"compressa"* by Cushman and Waters (1928) is undoubtedly a laterally compressed form of *T. conica*.

FIGURE 4. Flechado Formation Foraminifera, echinoderms, *Spirorbis* and ichthyoliths. Scale bars in microns. A–B, *Endothyra tortilis;* C, Ichthyolith type C, tooth; D–E, *Ammovertella* sp., on brachiopod spine; F, *Litutuba delicata,* attached to crinoid fragment; G–H, Ichthyolith type A, dermal dentical, top and side views; I–J, Ichthyolith type B, paleoniscoid scale, top and bottom views; L–N, *Spirorbis* sp. B, top, bottom and surface close-up views; O, *Spirorbis* sp. A, top view; P–Q, *Spirorbis* sp. A, top view, close-up of wall structure with embedded framboid. R, *Litutuba delicata,* on a crinoid fragment.


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Tetrataxis corona **Cushman and Waters, 1928**
Fig. 3G–H

Tetrataxis corona Cushman and Waters, 1928, p. 65, pl. 8, figs. 10a–b.

Description—Test consisting of pointed initial cone surrounded by a flattened outer test area, ventral surface flat, with low folds formed by chambers covering apertures; typically with four chambers in the outer whorl.

Discussion—This species differs from *T. conica* in having a lower test. It is similar to and perhaps conspecific with *Tetrataxis planispiralis* Reitlinger, 1950.

Genus *Pseudostaffella* Thompson, 1942
***?Pseudostaffella* sp.**
Fig. 3K

Description—Test planispiral, highly inflated, composed of numerous narrow slightly inflated chambers; wall microgranular, calcareous.

Discussion—The rarity of this species precludes further analysis. Most of the work on this genus is done using thin section material beyond the scope of this study.

Fusulinidae genus and species indet.

Discussion—The lack of time and expertise in working with this complex but stratigraphically important group has precluded detailed identification of the forms involved. It is hoped future work can fill this gap in our knowledge of the Talpa fauna.

Class *Polychaeta* Grube, 1850
Genus *Spirorbis*
***Spirorbis* sp. A**
Fig. 4O–Q

Description—Tube tightly coiled, sinistral, small, with one single coil preserved; surface ornamentation consists of both spiral and annular features giving it a net-like surface consisting of square to rectangular slightly raised cells; some large specimens show well developed annular folds.

Discussion—This species seems most similar to *Spirorbis moreyi*, described by Branson (1937) from the Mississippian of Wyoming. Both species have a rectangular surface ornamentation. It differs in having depressed rather than raised spiral and growth-line ornamentation. The present species differs from *Spirorbis anthracosia* Whitfield, 1890, *Spirorbis kentuckiensis* Howell, 1964 and *Spirorbis elegans* Elias, 1957 in having spiral ornamentation and much less pronounced growth lines which are marked by grooves rather than ridges. It differs from *Spirorbis annulatus nodulosus* Hall, 1856 in having multiple spiral grooves rather than a raised ridge. Most other species of late Paleozoic *Spirorbis* are either unillustrated, and/or unnamed (i.e., Clifton, 1942; Lane, 1962; Plas, 1972).

***Spirorbis* sp. B**
Fig. 4L–N

Description—Coiling sinistral, surface makred by annular growth lines and short irregularly arranged bumps elongated parallel to the spiral growth direction; coils number 1.5, with outer coil enclosing inner coils, ending in a hemicyclic opening; attachment surface flat, lacking any impression of attachment material.

Discussion—This species does not closely resemble any previously described late Paleozoic species. It appears most similar to *S. elegans* Elias, 1957, differing primarily in lacking the very oblique annular ribs and spine-like ribs mentioned from that species.

***Spirorbis* sp. C**

Description—Small, sinistrally coiled tube with a few faint constructions, otherwise unornamented; coiling tight; tube not ascendant; opening hemicyclic.

Discussion—No other described species of late Paleozoic spirorbid is known to lack ornamentation. This species is not attached to a hard-bodied fossil, suggesting attachment to plants or perhaps crustaceans.

Class Crinoidea Miller, 1821

The crinoids are represented in the Flechado Formation at Talpa by numerous isolated fragments, including isolated stem and calyx fragments, brachial plates, and other ossicles. Only one complete calyx was recovered (Fig. 7G–H); it is small, pyriform, star-shaped in aboral view and very closely resembles *K. inaquosus* Webster and Lane (1970), differing in having apparently slightly greater depression of the OO (oral) plates, more pointed beveled annulation on the RR (radial) plates, smaller BB (basal) plates and being distinctly higher than wide.

Subclass Ophiuroidea Gray, 1840

The Flechado Formation at Talpa contains a number of echinoderm fragments of opiuroid affinities or probable ophiuroid affinities. The most distinct and characteristic such fragments are the vertebral ossicles. At least three types can be distinguised. One type (ophiuroid type A, Fig. 5A–E) consists of an elongate arm ossicle, triangular in cross section with a very high dorsal ridge; prominent adoral hinge, extending posteriorly near the ventral side; dorsal nose prominent, pointing slightly dorsal from parallel; aboral ridge a small, rounded bump; ventral nose small, at low ventral position; musculature fields small, poorly defined; surface with many smoothed, rounded pits, aboral and adoral surfaces more porous. This ossicle closely resembles "Ophiuroidea sp. A" of Weller (1930).

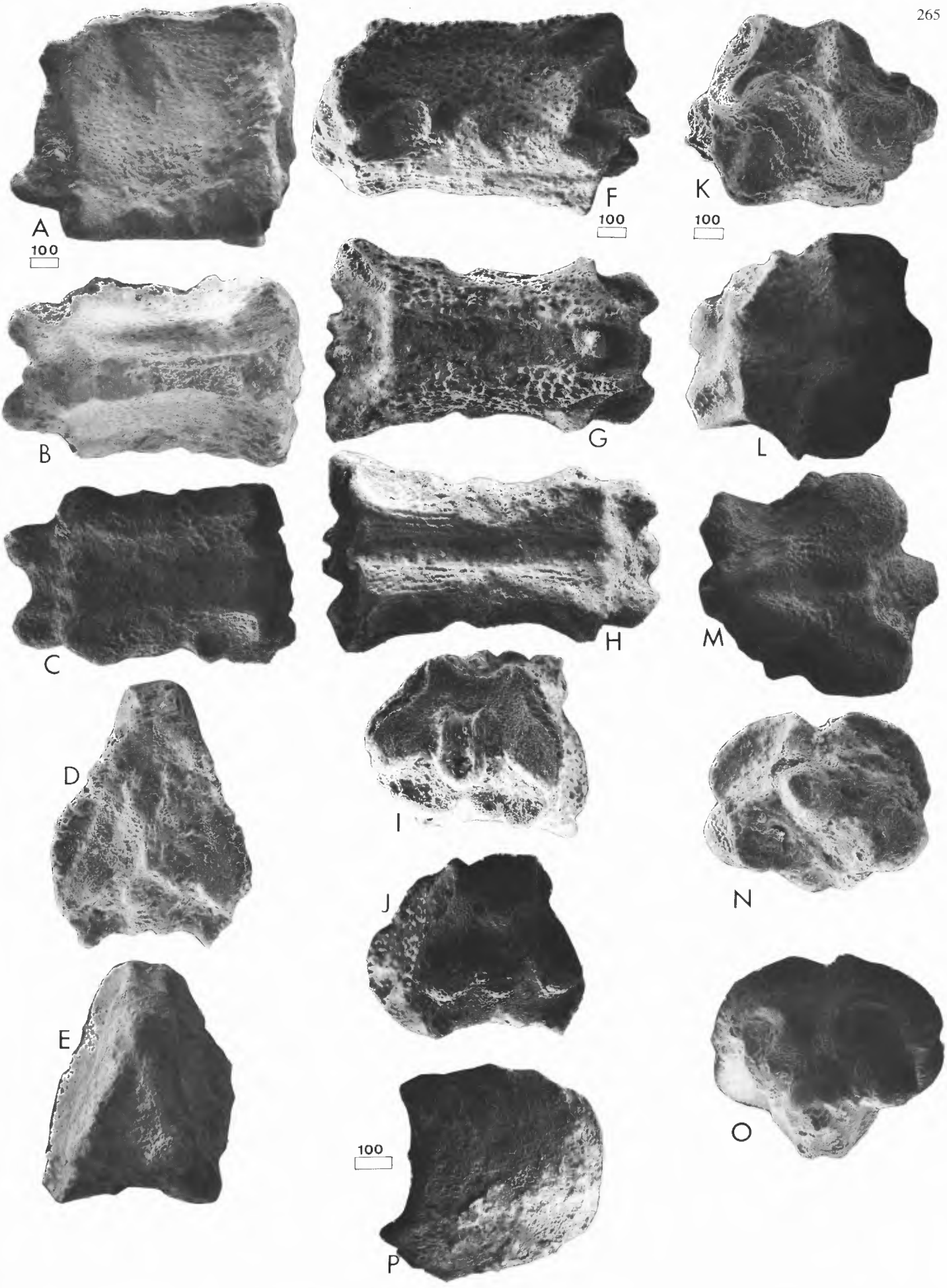
A second type (ophiuroid type B, Fig. 5F–J) of arm ossicle consists of an elongate, complex shape; highly porous, with many attachment surfaces for the dorsal and ventral longitudinal muscles; lateral surface with aboral end having an extended aboral hinge; podial basin deep but relatively small; ventral muscle field large, ellipsoidal; adoral hinge poorly developed, dorsal nose low, bifurcated, well developed; ventral nose flattened, low; adoral wings of moderate size, larger than aboral wings; dorsal muscle field well developed, ellipsoidal, dorsal groove extending across entire surface; lateral muscle field small, deep. This ossicle type does not resemble any described late Paleozoic species.

Another vertebral ossicle type (ophiuroid type C, Fig. 5K–O) is short, wide, inflated, with a rounded, saddle-like dorsal surface; aboral hinge large, rounded, inflated; ventral nose prominent, round, similar to dorsal nose; ventral groove narrow, located along narrow ventral ridge; dorsal muscle field prominent, rounded to slightly elongated; ventral muscle field very large, rounded; surface porous, with prominent pitting. This ossicle somewhat resembles Weller's (1930) "Ophiuroidea type C" but differs in being shorter and inflated. Some more elongate, smaller versions of the ossicle type were also recovered and are thought to represent more distal ossicles.

Some ossicles tentatively assigned to the Ophiuroidea are four or five pointed plates (ophiuroid type D, Fig. 6A–C) with a truncated spine projecting at 90° from one side, rounded, inflated, slightly irregular in shape and very porous; outer surface rounded, resembling an inflated echinoid ambulacral plate; ?inner surface with a large truncated spine about 1/4 as wide as the plate; spine with narrow, inflated, bifurcating ridges developed around base, otherwise porous like the plate. These plates somewhat resemble those of *Stuertzaster* (Spencer and Wright, 1966) but are more rounded and appear more porous. Their assignment to the ophiuroides is tentative; other asteroidean affinities are also possible.

Possible ophiuroid pedicellaria (ophiuroid type E, Fig. 7P) have been found in the Flechado material. They consist of minute jaw-like pieces with several recurved teeth. The "teeth" are sharp, recurved and fused to the "jaw." They appear to decrease in size toward the rear. This fragment type has been previously described by Wernlund (1977) as Problematica. They are very similar to his "type 2" Problematica which

FIGURE 5. Ophiuroids. Scale bars in microns. A–E, Ophiurian type A, vertebral ossicle, side, dorsal, ventral, aboral, adoral views; F–J, Ophiurian type B, vertebral ossicle, side, dorsal, ventral, aboral, adoral views; K–O, Ophiurian type C, vertebral ossicle, side, dorsal, ventral, aboral, adoral views; P, Ophiurian type I, lateral shield.


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he noted may be of ophiurian origin. They have distinct similarities to the pedicellaria jaws of the Asteroidia, but they may come from asteroid groups other than the ophiuroids.

Two minute spines of possible ophiuroid affinities have been found in the Flechado material. The first spine type (ophiuroid type F, Fig. 6H) have two or three branches at the end of a short shaft extending from a pitted, slightly inflated base. These minute spines could be from any of several echinoderm groups, but they most likely are from either echinoids or ophiurians.

The second spine type (ophiuroid type G, Fig. 6I) are minute with a relatively large porous base and a pointed shaft with rows of small conical bumps along the sides. These spines may be the backward directed spines from the ophiuroid lateral shields, but they could also belong to an echinoid.

A very distinctive structure (ophiuroid type H, Fig. 6S–T) is a serrated, flat, thin, tooth-like, subtriangular plate, with the upper surface having a series of small, projecting "teeth," all pointed forward. This fragment is thought to represent an ophiuroid jaw plate. Morris et al. (1973) described a similar jaw from an ophiuroid from the Conemaugh Group (Brush Creek Shale, Pennsylvanian) of Pennsylvania. The present material differs from that described by Morris et al. (1973) in having a serrated edge.

Lateral shields of ophiuroids (ophiuroid type I, Fig. 5P) are rather common in the Flechado material. They are elongate, curved plates with a row of spine attachment mamelons along the posterior margins. The lack of detailed illustrations of lateral shields for most described Carboniferous species makes assignment premature; certainly it is totally unlike the well illustrated shields of *Armathyraster paradoxis* Harper and Morris, 1978. It resembles in many ways the lateral shields attributed to *Ophiomusium* and related genera from the Cretaceous by Hess (1962).

Class Echinoidea

Echinoid fragments are found in megafaunal samples as well as microfaunal samples from the Talpa localities. In the microfaunal samples many different elements are represented. Among the most interesting elements (echinoid type A, Fig. 6P–Q) are ophicephalous pedicellaria valves, with distal end leaf-shaped; outside textured, inside with small, regular marginal bumps along the upper margin, rows of larger bumps occur along the side margins outlining the central cavity; distal end connected to the proximal by a textured, relatively long, round, hollow neck; proximal end about same size as distal end, more pointed, smooth on the outside, inner side not observed. This form most resembles a type illustrated by Geis (1936, pl. 59, figs. 28–34) from the Graham Formation of Texas. The distal end of the present species does not appear to be as rounded as those illustrated by Geis.

Another group of echinoid fragments consists of the Aristotle's lantern. Pyramids (echinoid type B, Fig. 6D–F) are small, roughly triangular to wedge-shaped in side view; inside with a rectangular, flat, articular surface marked with longitudinal groove/ridges; outer side with rectangular brace and half-rounded muscle-scar groove; tooth-support area worn and broken. Both Geis (1936) and Spreng and Howe (1963) described and illustrated several pyramids from late Paleozoic echinoid lanterns, but the present specimen is not clearly like any of those previously illustrated.

Another element of the Aristotle's lantern recovered from the Flechado is the rotula or brace elements (echinoid type C, Fig. 7M), which are large, nearly rectangular, relatively thin, both ends flaring slightly; tooth end smaller, "phlange"-like, with a shallow notch for holding the tooth; articular end heavier with muscle attachment surfaces on each side. Geis (1936) illustrated several types of isolated rotulae from the late Paleozoic of Illinois and Texas. Although similar to specimens from the LaSalle cyclothem of Illinois and the Graham Formation of Texas, the present specimens differ in having a more transverse articular end.

Another element of the Aristotle's lantern represented is the epiphysis (echinoid type F, Fig. 6G). The incomplete nature of this specimen makes comparison difficult. The large foramen would clearly separate this specimen from any described and illustrated by Geis (1936).

The final element from Echinoidea Aristotle's lantern recognized consists of the tooth (echinoid type G, Fig. 6M–O), a subrectangular, thin, calcareous, recurved plate pointed at one end. The plate appears to be composed of three fused plates about three times as long as wide; with one end irregularly rounded and the other end with a longer central, wedge-shaped point and two or three side points on each side of the central point. This echinoid fragment is difficult to compare with any other echinoid due to the poor illustrations of the element in other works. Descriptions in the *Treatise* (Durham et al., 1966) suggest this tooth may be cideroid or aulodont in nature since it lacks an interior keel.

Other common echinoid elements in the Talpa material consist of large spines (echinoid type D, Fig. 6J) with numerous vertical ridges. Geis (1936) illustrated several echinoid spines resembling those from Talpa, including specimens from the Graham and Mineral Wells Formations of Texas and the Shelterville Member of the Renault Formation of Illinois. Also commonly found are various ambulacral plates (echinoid type E, Fig. 6R), although the relationships of most individual ambulacral plates have not been worked out well enough to make comparisons valid.

Class Holothuroidea Blainville

Genus *Tetravirga* Frizzell and Exline, 1955

Tetravirga sp. aff. *T. etheridgei* Frizzell and Exline, 1955

Fig. 7I–J, O

Description—Bar-like forms in a cross shape with a slightly offset center bar; ends of spokes flattened and perforated, with slightly inflated outer edge; perforations irregular in size and shape, up to 10 in number. Variations of the cross-shaped spokes are some with H-shaped spokes with shorter spokes tipped with elongate perforated ends.

Discussion—This species is similar to *Tetravirga ethridgei* Frizzell and Exline, 1955 but differs in having a cross bar rather than a simple cross at the center. Some fragments probably belonging to this form also have another cross bar in a plane perpendicular to the one illustrated. The tips of the spokes of *T. etheridgei* appear flattened, but they appear to be broken off and thus are unknown.

Genus *Eocaudina* Martin, 1952 emend. Frizzell and Exline, 1955

Eocaudina gutschicki Frizzell and Exline, 1955

Fig. 7F

Eocaudina gutschicki Frizzell and Exline, 1955, p. 87, pl. 3, figs. 7–8.

Description—Sclerites composed of perforated plates of rounded hexagonal shape, with round perforations, arranged in a series of 8, rarely 9, in a maximum-length row; edges formed by growth rings around perforations.

Discussion—As noted by Frizzell and Exline (1955), *Eocaudina gutschicki* most resembles *Eocaudina mccormacki* Frizzell and Exline, 1955. It differs in having fewer perforations in a row, and larger and less uniform-sized perforations.

Genus *Achistrum* Etheridge, 1881

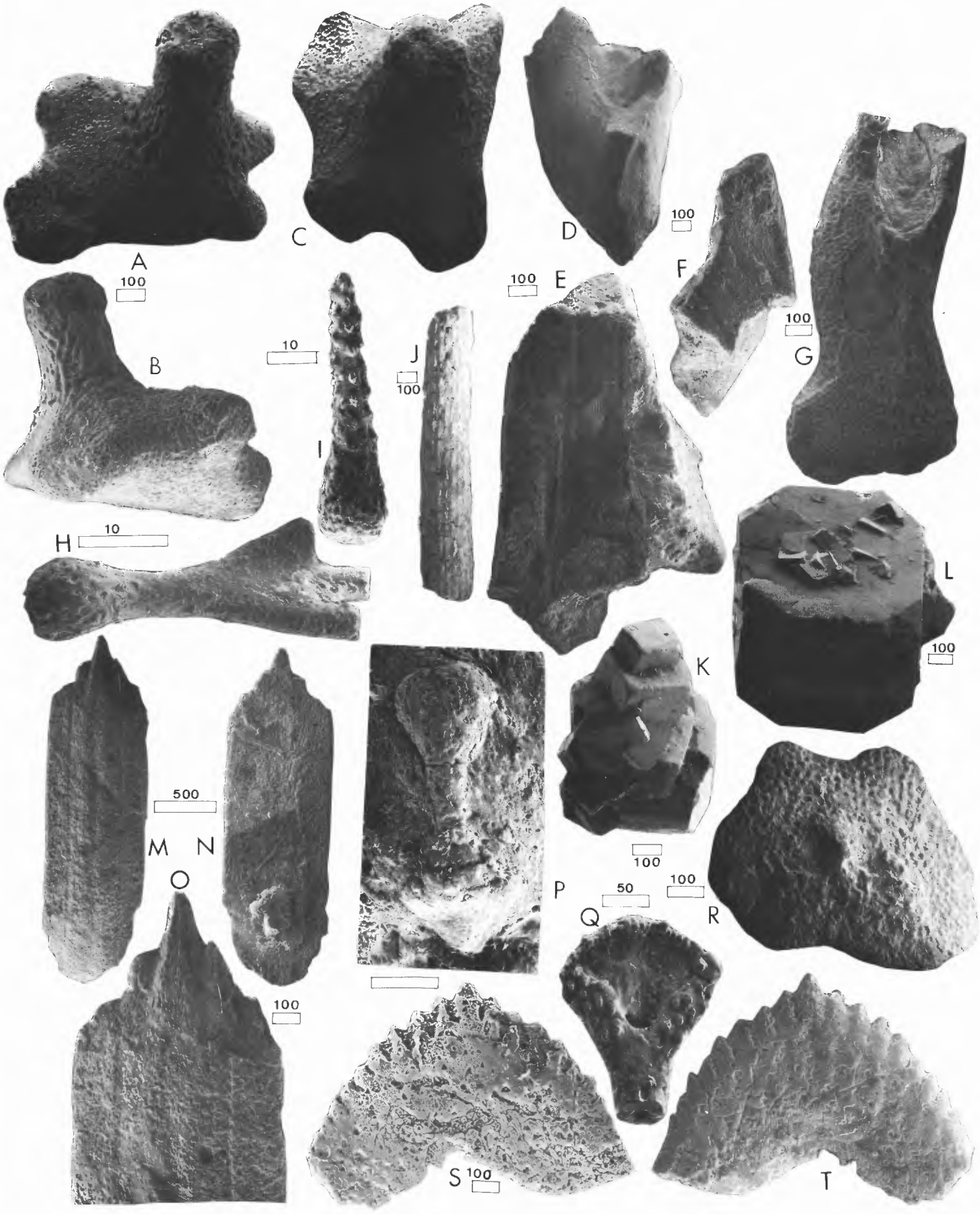
Achistrum sp. cf. *A. gamma* Hodson, Harris, and Lawson, 1956

Fig. 7K–L

Achistrum gamma Hodson, Harris, and Lawson, 1956, p. 340, text fig. 12.

Description—These sclerites consist of small narrow hooks with long shafts and a slightly tilted eye, usually with a single opening that is rarely separated with a bar into two holes; the eye is formed by the end

FIGURE 6. Flechado Formation Echinodermata and minerals. Scale bars in microns. A–C, ?Ophiurian type D, ossicle, top, oblique, side views; D–F, Echinoid type B, left pyramid, inside, articular, outside views; G, Echinoid type F, epiphysis, outside view; H, Ophiurian type F, spine; I, Ophiurian type G, spine; J, Echinoid type D, spine; K–L, Pyrite cubes; M–O, Echinoidea type G, top, bottom, close-up; P, Echinoid type A, pedicellaria, face view; Q, Echinoid type A, pedicellaria, back view; R, Echinoid type E, ambulacaral plate, top; S–T, ?Ophiurian type H, tooth, top, bottom views.


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of the tapered shaft, which is narrow where it is fused with the shaft.

Discussion—The small delicate nature of the Flechado specimens is similar to *Achistrum gamma*. This species has previously only been reported from the Allen Mountain Limestone (Mississippian) of Montana and the Chouteau Limestone (Mississippian) of Missouri.

Achistrum sp.
Fig. 7N

Description—Sclerite consists of a hook, with the hook shank straight and not notably tapering. It lacks the eye that is usually used to characterize species of this genus.

Discussion—The large size and heavy structure of this sclerite separates it from the previous one, but the lack of an eye precludes more detailed comparisons.

Genus *Thalatocanthus* Carini, 1962
Thalatocanthus consonus Carini, 1962
Fig. 7D–E

Thalatocanthus consonus Carini, 1962, pp. 392–394, pl. 1, figs. 1–23, text figs. 1–7.

Description—Sclerites minute, wheel-shaped, with 11 triangular perforations around the central hub, separated by raised triangular spokes; center consisting of a raised hollow hub.

Discussion—No other species of this genus has been recognized.

Genus *Protocaudina*
Protocaudina kansasensis (Etheridge, 1881)
Fig. 7A–C

Lsetmophasma(?) *kansasensis* Hanna (in part), 1930, pp. 413–414, pl. 40, figs. 1–2, 4–7.

Caudina traquairii Croneis (in part), 1931, pp. 47–47 [name suggested but not used].

Protocaudina kansasensis: Croneis and McCormack, 1932, pp. 138–139, pl. 20, figs. 2, 6.

Description—Sclerites wheel-shaped, with 4 pie-shaped or round inner perforations in the center and 10 round to irregularly round perforations around the outside; rare specimens with a few extra partial perforations attached outside the wheel; central area slightly raised.

Discussion—*Protocaudata kansasensis* has a greater number of outer perforations and a less distinctly raised center than has *Protocaudina traquairii* (Etheridge, 1881).

Subclass *Ostracoda* Latreille, 1802
Genus *Hollinella* Coryell, 1928, emend. Kellett, 1929
Hollinella sp.
Fig. 9S–T

Description—Valves large with well developed medial sulcus (S2), low confluent L1, indistinct confluent L2, L3 large, round, about 1/4 length; L4 indistinct; dorsal margin straight, ending posteriorly in an oblique oriented spine; velate ventral ridge extending from the anterior margin to just beyond L3 along the ventral margin; surface distinctly but finely reticulated, L3 more finely ornamented than rest of valve. Valves highly dimorphic with males having much narrower frills than females and immature forms lacking frills.

Genus *Kirkbya* Jones, 1859, emend. Knight, 1928
Kirkbya inornata Roth, 1929
Figs. 8C, 9E–F

Kirkbya inornatum Roth, 1929, p. 14, pl. 1, figs. 1a–c.

Kirkbya inornata Shaver and Smith, 1974, pp. 49–50, pl. 3, figs. 5–8.

Description—Valves subrectangular; dorsal margin straight, ventral margin straight, swinging smoothly up anteriorly and posteriorly to meet dorsal margin at slightly greater than 90°; ventral, anterior and posterior margins with distinct marginal rim; valve surface with rounded reticulations of about even size over valve surface, reticulations about 32 μm in diameter; greatest width of valves slightly posterior of center; valve with slight subcentral low area separating anterior and posterior shoulders.

Discussion—This species is very similar to *Kirkbya bendensis* (Harlton, 1933), differing in having finer reticulation, a less truncated anterior margin and a less well-developed lobation.

Kirkbya fuldaensis Shaver and Smith, 1974
Fig. 8H–I

Kirkbya fuldaensis Shaver and Smith, 1974, pp. 48–49, pl. 3, figs. 1–4.

Kirkbya cf. *K. fuldaensis* Becker, 1978, p. 54, pl. 2, figs. 14a–b.

Kirkbya reflexa Girty. Cooper, 1946, p. 106, pl. 17, figs. 1–2 [not 3–4].

Kirkbya sp. Thompson and Shaver, 1964, p. 13–14, fig. 2.

Discussion—Valves elongate suboval with anterior end higher and posterior more pointed than anterior; dorsal margin straight; anterior, ventral and posterior margins convex curved with a distinct posterior swing; posterior cardinal angle about 40°, anterior angle less small but obscured by valve damage; valve surface with elongated oval reticulations of approximately equal size over valve surface; reticulations about 43 by 19 μm; greatest width slightly posterior of midpoint.

Discussion—Ostracods of this type, although usually placed in the genus *Kirkbya*, are probably better placed in a separate genus or at least subgenus characterized primarily by the ovoid rather than subquadrate shape and lack of marginal rims.

Genus *Amphissites* Girty, 1910, emend. Knight, 1928
Amphissites centronotus (Ulrich and Bassler, 1906)
Figs. 8A–B, 9M–O

Kirkbya centronota Ulrich and Bassler, 1906, p. 159, pl. 11, figs. 16–17.

Amphissites centronota Harlton, 1927, p. 207, pl. 32, figs. 10a–b.

Amphissites centronata: Sohn, 1961, pp. 118–119, pl. 7, figs. 8–10 [see for complete synonomy to 1961].

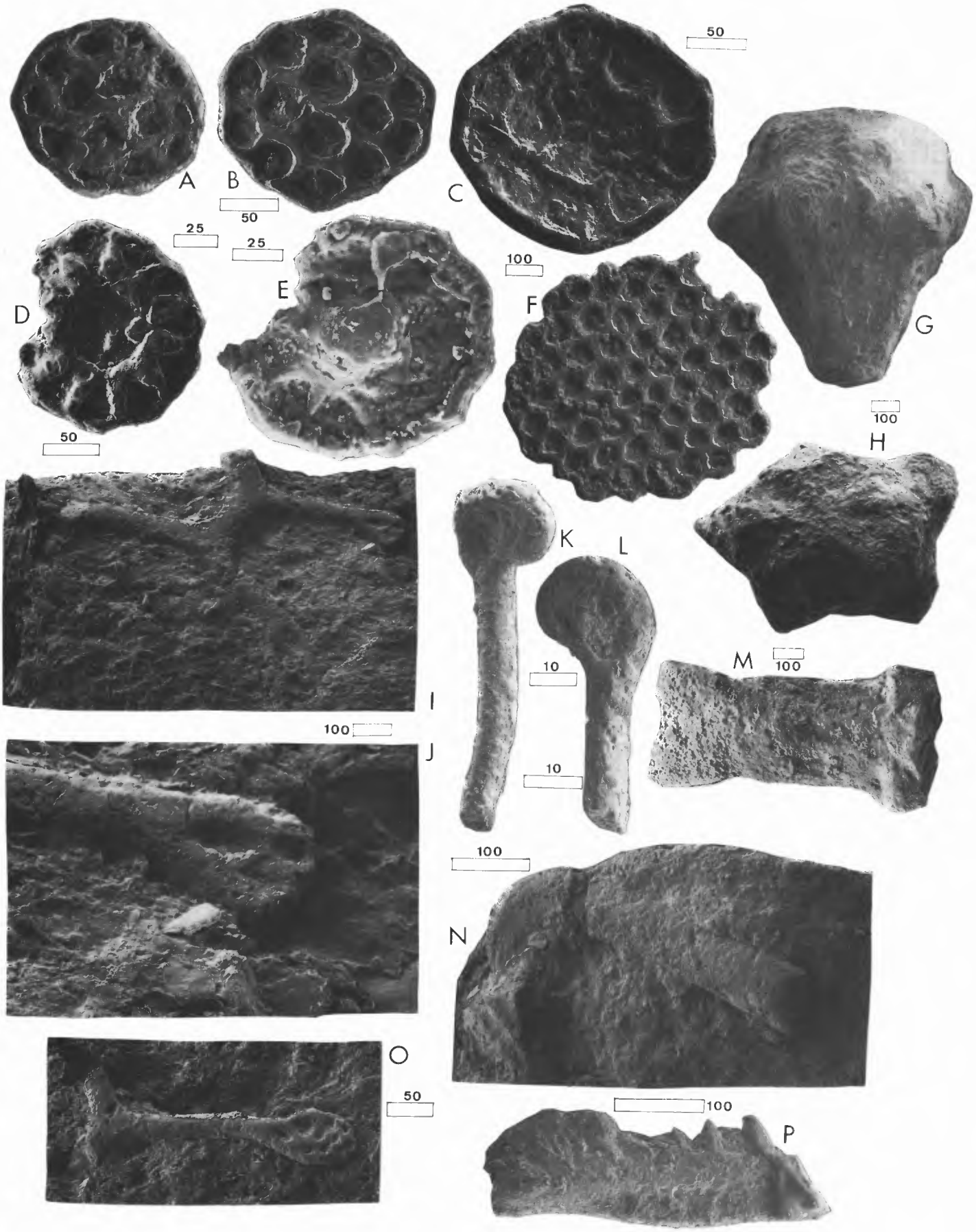
Description—Valves subquadrate, with marginal rims, anterior and posterior carinae, and a subcentral node lacking carinae; dorsal margin straight, ventral margin straight, curving evenly up at posterior and anterior ends to meet dorsal margin at rounded cardinal angles; surface with polygonal reticulations, those on central node about 19 μm in diameter; greatest width of valves at central node.

Discussion—Shaver and Smith (1974, p. 37) questioned Sohn's (1961) assignment of several Mississippian species to this species based on morphological criteria: ". . . the specimens originally designated by the names *Amphissites similaris* Morey and *A. truncatus* Sohn have morphologies that are so close to that of middle Pennsylvanian specimens of *A. centronotus* as to justify on a strictly morphological basis their assignment to *A. centronotus*." These authors go on to suggest homeomorphy as the cause of this apparently long range and the fact that their restriction to lower-middle Pennsylvanian rocks would make them useful stratigraphic indicators. I fail to understand how homeomorphic species so close as to be morphologically inseparable could possibly be of biostratigraphic value. Also, the homeomorphy remains to be proven.

Amphissites sp.
Fig. 8N–O

Description—Carapace rounded, rectangular; dorsal and ventral margins straight; anterior and posterior margins evenly rounded; ornamentation consisting of weak central node, anterior and posterior

FIGURE 7. Flechado Formation Echinoderms. Scale bars in microns. A, *Protocaudina kansasensis*, top view; B, *Protocaudina kansasensis*, top view; C, *Protocaudina kansasensis*, underside; D–E, *Thalatoconthus consonus*, top and bottom; F, *Eocaudina gutschicki*, top view; G–H, *Kallimorphocrinus* sp., side and top views; I–J, *Tetravirga* sp., overview and detail; K, *Achistrum gamma*, eye of hook; L, *Achistrum gamma*, eye of hook; M, Echinoid type C, brace, top view; N, *Achistrum* sp., hook; O, *Tetravirga* sp., end of spine tip; P, Ophiurian, pedicellaria, side view.


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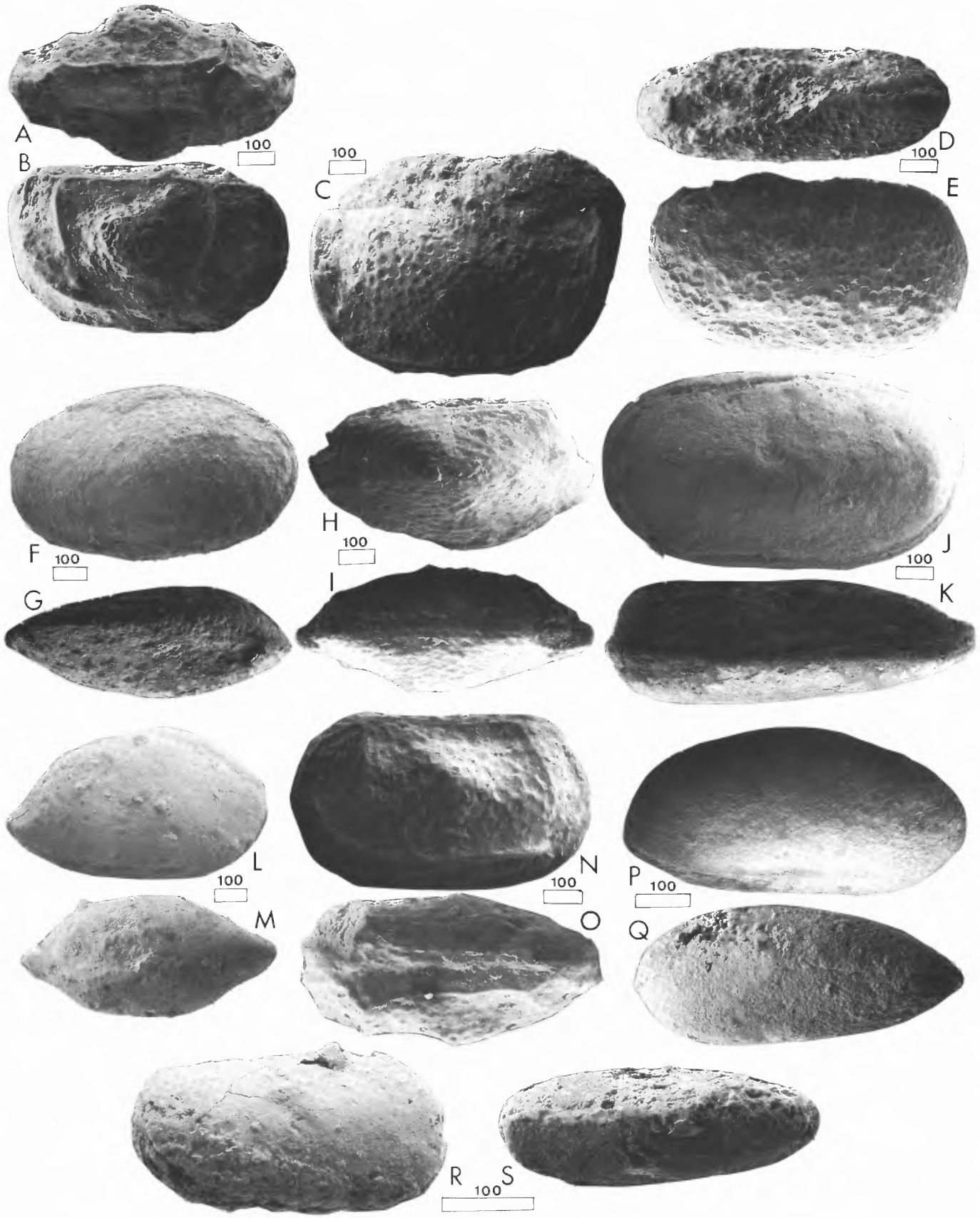


FIGURE 8. Flechado Formation Ostracoda. Scale bars in microns. A–B, *Amphissites centronotus,* dorsal and left side views; C, *Kirkbya inornata,* right side view; D–E, *Roundyella simplicissima,* dorsal and right side views; F–G, *Cavellina rotunda,* left side and dorsal views; H–I, *Kirkbya fuldaensis,* right side and dorsal views; J–K, *Sulcella sulcata,* right side and dorsal views; L–M, *Orthobairdia oklahomensis,* right side and dorsal views; N–O, *Amphissites* sp., right side and dorsal views; P–Q, *Pseudobythocypris pediformis,* right side and dorsal views; R–S, *Youngiella* sp., right side and dorsal views.

carinae; 2 marginal carinae, the inner of which ends anteriorly near end of anterior carinae, posteriorly sweeping up to the dorsal margin; in dorsal view valve elongate, subtriangular; dorsal shield present; central nodes with slight posterior asymmetry; surface with even-sized reticulations over central node.

Discussion—The species is somewhat similar to *Amphissites centronotus,* but differs in having a weaker central node, even reticulation pattern over node and valve, more triangular shape in dorsal view, and a stronger development of the inner marginal carinae.

Genus *Roundyella* Bradfield, 1935
Roundyella simplicissimus (Knight, 1928)
Fig. 8D–E

Amphissites simplicissimus Knight, 1928, p. 266, pl. 32, figs. 11a–d, pl. 34, fig. 6.
Roundyella simplicissimus Bradfield, 1935, p. 66.

Description—Valves ovoid, subrectangular; dorsal and ventral margins straight; posterior and anterior margins evenly rounded, anterior margin very slightly less acute than posterior; surface with polygonal reticulations of about even size across the valve, reticulations about 31 μm across, surface also with evenly distributed minute spines at intersections of some inter-reticulation ridges at a spacing of about 100 μm; greatest valve width at about midlength.

Discussion—This widespread and common species is easily recognized and not likely to be confused with other species.

Genus *Youngiella* Jones and Kirkby, 1895
Youngiella sp.
Fig. 8R–S

Description—Valves minute, subrectangular; dorsal and ventral margins straight; anterior margin evenly rounded, posterior margin more acute than anterior, evenly rounded; overlap not detected; shell material thin; anterior more pointed in dorsal view.

Discussion—There has been some confusion regarding the separation of *Youngiella* from the related genus *Moorites*. I have found the absence of anterior and posterior rims in *Youngiella* to be taxonomically useful even when dealing with otherwise unornamented late instars.

Genus *Coryellina* Bradfield, 1935
Coryellina capax Bradfield, 1935
Fig. 9C–D, P–R

Coryellina capax Bradfield, 1935, p. 36, pl. 1, figs. 11a–b.

Description—Valves highly inflated posteriorly, with posterior spine at most posterior point of valve; right valve overlaps left on all margins, greatest on ventral and dorsal margins; dorsal margin straight in lateral view, slightly pointed at posterior end; valves with posterior trending swing, evenly rounded; some specimens displaying an area of faint, elongate small reticulations near the posterior spine area and ventrally; SEM examination suggests this "reticulation" may reflect carapace internal structures possibly expressed on the surface by compression.

Discussion—*Coryellina capax* is a Middle Pennsylvanian species of an evolutionary lineage spanning the Mississippian to the Permian. Sohn (1962) showed that the position of the posterior spine migrated from a ventral to a dorsal location during this period.

Genus *Bairdia* McCoy, 1844
Bairdia grahamensis Harlton, 1928
Fig. 9K–L

Bairdia grahamensis Harlton, 1928, p. 139, pl. 21, fig. 11.

Description—Valves large, inflated in central area; anterior and posterior somewhat flattened; dorsal margin arched in middle; anterior and posterior slopes nearly equal, flat to very slightly concave; ventral margin straight, turning up at ends evenly; posterior point below the valve center, slightly upturned; anterior end slightly pointed, about at valve midpoint; greatest height slightly posterior of midpoint, greatest width at about midpoint; left valve overlaps right, especially along the dorsal and anteroventral margins.

Discussion—This common Pennsylvanian species is unlikely to be confused with others.

Orthobairdia oklahomensis (Harlton, 1927)
Figs. 8L–M, 9I–J

Bairdia oklahomensis Harlton, 1927, p. 209, pl. 33, fig. 7.
Orthobairdia oklahomensis Sohn, 1960, pp. 66–67, pl. 3, figs. 13–21 [see for synonymy through 1960].

Description—Valves medium sized, left valve overlapping right, most pronounced on dorso-anterior margin; dorsal margin arched; ventral margin nearly straight, anterior margin rounded; posterior margin pointed, point slightly ventral of midheight; greatest height slightly anterior of midpoint; in dorsal view sides flattened, parallel, greatest width at about midpoint, anterior more elongated than posterior.

Discussion—This common, widespread Pennsylvanian species is easily recognized and unlikely to be confused with others from the Pennsylvanian.

Genus *Bairdiacypris* Bradfield, 1935
Bairdiacypris hoxbarensis (Harlton, 1927)
Fig. 9G–H

Bairdia hoxbarensis Harlton, 1927, p. 211, pl. 33, fig. 12.
Fablicypris hoxbarensis Sohn, 1960, p. 63 [includes a good synonymy].

Description—Valves elongate, suboval; dorsal margin slightly convex; ventral margin straight to slightly concave; anterior margin rounded, posterior margin with blunted bairdiacean point; point at about midheight; overlap most pronounced ventrally and dorsally; greatest height anterior of center, about 1/3 distance from anterior margin; in dorsal view greatest width at 1/4 length from posterior margin, tapering toward anterior margin, more acutely tapering toward posterior margin.

Comparisons—This widespread and common species is unlikely to be confused with others.

Genus *Healdia* Roundy, 1926
Healdia sp.
Fig. 9C–D

Description—Valves small, thin; oval in lateral view, with posterior ridge; dorsal and ventral margins convex, about equal, anterior margin more acute than posterior margin, both evenly rounded; greatest height at about midlength; shape in dorsal view subtriangular, anterior pointed, greatest width slightly anterior of posterior ridges; left valve overlaps right, greatest anteriorly.

Discussion—Rarity and relatively poor preservation makes comparisons of the Flechado material difficult. In dorsal view this species resembles *Healdia simplex* Roundy, 1926, but differs in being less arched dorsally and in having a more pronounced posterior ridge. In side view it resembles *Healdia miranda* Coryell and Billings, 1932 but is more rounded anteriorly.

Genus *Pseudobythocypris* Shaver, 1958
Pseudobythocypris pediformis (Knight, 1928)
Fig. 8P–Q

Bythocypris pediformis Knight, 1928, pp. 326–327, pl. 44, figs. 3a–c.
Pseudobythocypris pediformis (Knight): Shaver, 1958, pp. 120–136, text fig. 1 [see for synonymy through 1958].

Description—Valves suboval, elongate, small; dorsal margin gently arched; ventral margin straight; anterior margin evenly rounded; posterior margin with posterior ventral acute angular "point"; left valve overlapping right along ventral margin, slight elsewhere; greatest height at about midpoint; in dorsal view pointed anteriorly, rounded posteriorly, greatest width about 1/4 length from posterior margin.

Discussion—This species is widespread and morphologically somewhat variable, as well as dimorphic, leading to a large number of synonyms among early workers. Thanks to the efforts of Cooper (1946) and Shaver (1958), the taxonomy of this species has stabilized.

Genus *Silenites* Coryell and Booth, 1933
Silenites lenticularis (Knight, 1928)

Carbonia? lenticularis Knight, 1928, p. 335, pl. 44, figs. 9a–b.
Silenites lenticularis Kellett, 1935, p. 151, pl. 17, figs. 9a–i.

Description—Valves fairly large, stout, left valve overlaps right on all margins; dorsal margin arched; ventral margin slightly concave; anterior and posterior margins evenly rounded; surface smooth.

Comparisons—This species differs from *S. silenus* Coryell and Booth, 1933 in being more elongate. It also differs in this respect from several species recently described from China (Xiu-gao and Jin-hua, 1987).

Genus *Cavellina* Coryell, 1928, emend. Kellett, 1935
Cavellina rotunda Cooper, 1946
Fig. 8F–G

Cavellina rotunda Cooper, 1946, p. 74, pl. 10, figs. 19–21.

Description—Valves oval; right valve overlapping left on posterior, dorsal and ventral margins; dorsal and ventral margins evenly arched; posterior margin rounded, with slight dorso-anterior angularity, anterior margin evenly rounded, greatest height slightly posterior of midpoint; in dorsal view anterior tapered and pointed, posterior more bluntly pointed, greatest width at about 1/4 length from posterior margin.

Discussion—This species resembles *Cavellina nebrascensis* (Geinitz, 1867) but is much smaller in average size. It also has more parallel dorsal and ventral margins than most other described species.

Genus *Sulcella* Coryell and Sample, 1932
Sulcella sulcata Coreyll and Sample, 1932
Fig. 8J–K

Sulcella sulcata Coryell and Sample, 1932, p. 275, pl. 26, fig. 18.

Description—Valves subrectangular, oval; right valve overlaps left on all margins, most strongly on dorsal and ventral margins; dorsal margin slightly convex with peak angulation slightly posterior of midline; ventral margin slightly concave; anterior margin evenly rounded, posterior margin with dorso-posterior angulation; surface smooth, with low subtriangular sulcus slightly anterior of midpoint; greatest width slightly posterior of midpoint.

Discussion—Although the correct generic assignment of this species among early workers resulted in some synonymy, the taxonomy of this species has stabilized, and it is not likely to be confused with other described species.

VERTEBRATA

A number of vertebrate ichthyoliths were recovered from the Flechado samples. These include a ?dermal denticle, ichthyolith A (Fig. 4G–H), probably broken, consisting of three teeth on a dermal platform; teeth have conspicuous ridges, some bifurcating that radiate down from the tip; the largest tooth has about 9 ridges. This ichthyolith can be assigned to Tway (1979) type: a11/b2/c1/d6/e1/f3–5/g1/h2. This ichthyolith is very similar to one illustrated by Tway and Zidek (1983, figs. 41a–c) from the Late Pennsylvanian of Kansas. It differs in having greater spacing between the teeth, and fewer ridges on the teeth.

Another ichthyolith type (ichthyolith B) is a ?paleoniscoid scale (Fig. 4I–J), which is rhombohedral, flat, thin and minute, with the outer surface marked by about 3 low ridges. The posterior margin has 2 small points. This ichthyolith is Tway (1979) type: a3/b2/c4/d3/e1/f1/g1,2. It resembles one illustrated by Tway and Zidek (1982, figs. 47a–c) from the Late Pennsylvanian of Kansas, differing in having fewer and less distinct surface ridges and in having a more diamond-like shape.

A third ichthyolith type (ichthyolith C) is a small, single tooth (Fig. 4C) characterized by a transluscent tip, the axis of which is curved and the apex of which is blunt. It has a length about 3 times its diameter. This ichthyolith is Tway (1979) type: a9/b5/c2/d1,2/e7/f2,3/g1. It is identical to one illustrated by Tway and Zidek (1983, fig. 5a, b) from the Shawnee Group (Late Pennsylvanian) of Kansas and Missouri. It seems likely these ichthyoliths are teeth from small fish.

A final ichthyolith type (ichthyolith D) is a platformed denticle, backward sweeping with the width greater than the length. The upper surface has 5 low ridges, and the posterior margin has small denticles formed by the ends of the ridge extensions. The platform is roughly parallel to the upper surface and diamond shaped. This ichthyolith is Tway (1979) type: a5/b2/c2/d5/e3,4/f2,3. The present specimen is similar to a denticle illustrated by Tway and Zidek (1982, fig. 59) but is less acute posteriorly.

PALEOECOLOGY

The Flechado microfauna is not suitable for a detailed paleoecologic interpretation. A detailed interpretation must await a more quantitative and comprehensive approach than is possible at this time. The following is a generalized paleoecologic evaluation based on the fauna as presently known.

Modern Foraminifera can be found in most marine or marginal marine situations; however, they show preferences and paleoecologic inferences can be drawn from the relative abundance of particular foraminiferal groups and from the overall diversity of the faunas. The Flechado foraminiferal fauna is characterized by a mixture of calcareous mobile forms, including fusulinids and abundant adherent agglutinated forms. The diverse calcareous fauna, particularly the fusulinids, suggest an open connection to the normal marine environment. This foraminiferal association is characteristic of the biostrome facies of Ameron et al. (1970).

Yancy and Stevens (1981) described two offshore foraminiferal communities, the fusulinid community and the paleotextularid community. In both of these communities the forams are dominant elements. In the case of the Flechado, whereas forams may be common in some samples, they are not dominant. Even within the foraminiferal communities, usually the adherent agglutinated forams are dominant. This suggests open connections with offshore communities of the fusulinid and paleotextularid types, but not that the Flechado represents pure forms of these communities. The lack of wear and excellent preservation of even delicate endothyracean forams suggests reworking is not a factor in their distribution.

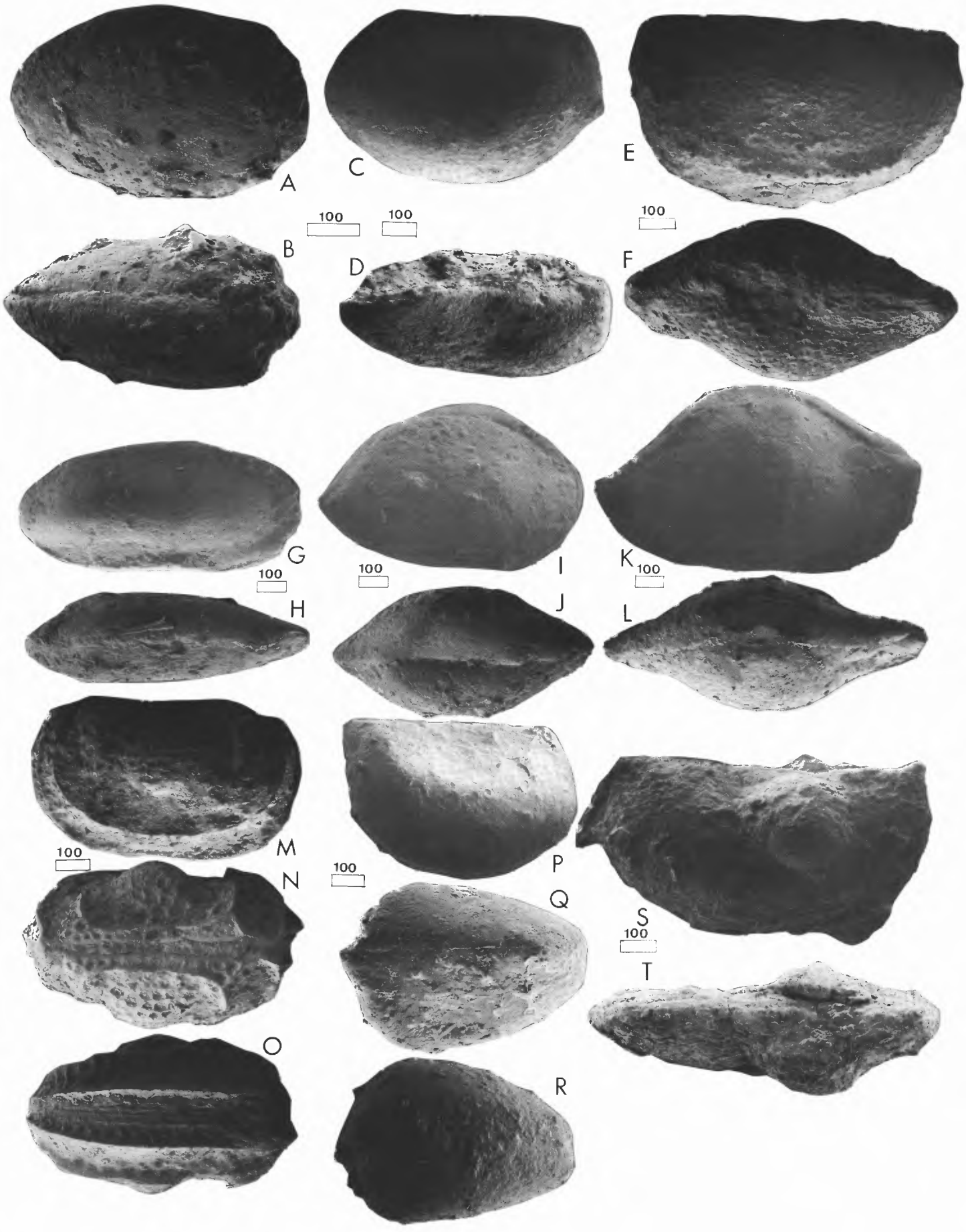
Many organisms were used as attachment sites for Foraminifera. Brachiopod fragments, especially productoid spines, are fairly common and often are substrates for attached forams. Bryozoans of both fenestrate and ramose types are common and occasionally used as attachment substrates for forams. Ostracods are also utilized as substrates for attachment.

The ecology of modern holothurians was summarized by Frizzell and Exline (1955). They are found in waters of normal marine salinity, and very rarely in slightly brackish habitats. Hampton (1959) indicated one dead holothurian might potentially be represented by 20,600,000 sclerites; thus, the presence of even large numbers of sclerites need not indicate particularly large original populations. Modern holothurians often have more than a single sclerite type, and therefore the diversity of holothurians in the Flechado is overestimated when based on number of form genera represented.

Modern ophiuroids are common in waters of normal salinity, and may reach densities as high as 710/m^2 (Reese, 1966). Most are either predators or filter feeders. As predators, they feed principally on microcrustaceans, although some species utilize larger prey, including molluscs and other echinoderms. The presence of ophiuroids in the mollusc-dominated assemblages of the Flechado is not unexpected.

Fragmentary echinoid remains are common in Pennsylvanian marine faunas. The relatively low density of echinoid remains in the Flechado samples suggests that the environment may not have been optimal for

FIGURE 9. Flechado Formation Ostracoda. Scale bars in microns. A–B, *Healdia* sp., left side and dorsal views; C–D, *Coryellina capax*, left side and dorsal views; E–F, *Kirkbya inornata*, left side and dorsal views; G–H, *Bairdiacypris hoxbarensis*, right side and dorsal views; I–J, *Orthobairdia oklahomensis*, right side and dorsal views; M–O, *Amphissites centronotus*, left side, dorsal and ventral views; P–R, *Coryellina capax*, right side, dorsal and ventral views; S–T, *Hollinella* sp., left side and dorsal views.


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them. Spine morphologies suggest one or possibly two forms were present in the Flechado.

Crinoid ossicles represent a significant part of the Flechado microfossil material. Only one complete calyx was found in the present study, but a multitude of other parts suggests crinoids were an important part of the overall fauna. The columnal surface structure and shapes suggest several different crinoids were present in the Flechado fauna, although the exact diversity is difficult to calculate. Since crinoids form from spicules of the sieve type (Clark, 1921), some spicules of this type lacking a distinct outer rim may represent larval crinoids, although they may also be derived from holothurians. Examples of these spicules have been seen in the Flechado material. Also, crinoid fragments in the Flechado are common substrates for attached Foraminifera.

Modern spirorbids are entirely marine to brackish, but there is evidence that some forms from the Triassic and late Paleozoic lived in nonmarine environments as well (Gotz, 1931; Kietzke, 1989). Stevens (1966) considered the marine species to be characteristic of very shallow (0–5 m), possibly euryhaline environments. Spirorobids are attached organisms. No trace of a hard attachment substrate was found with the present species; attachment to a plant or chitinous substrate is probable. Yancy and Stevens (1981) found *Spirorbis* to be most common in their euphemitid community, although it ranges into other communities as well.

The paleoecology of late Paleozoic ostracods has been studied by numerous workers, including Elias (1937), Lane (1964), Ameron et al. (1970), Haack and Kaesler (1980), Peterson and Kaesler (1980), Kaesler (1982), Kaesler and Denver (1988) and Melnyk and Maddocks (1988a). Melnyk and Maddocks (1988b) and Ameron et al. (1970) have done the most complete paleoecologic analysis of late Paleozoic ostracods to date.

The compositions of Flechado Ostracoda assemblages were analyzed by calculating percentages of the Kirkbyacea, Bairdiacea and all other groups (Fig. 10). These data indicate the Bairdiacea are dominant in all samples except B5 where they rank second and B7 where they are absent. The Kirkbyacea are absent in all samples except C3 (base) and gauging station sample R. This suggests that C3 (base) and R were deposited in ecologically similar situations. The strong presence of the Cavellinidae and Bairdiacypriidae in sample B7 is suggestive of a period following higher sedimentation when a mixture of opportunistic species (Cavellinidae) and equilibrium species (Bairdiacypriidae) became dominant, as suggested by Kaesler and Peterson (1989).

Among the Flechado ostracods are several species considered by Melnyk and Maddocks (1988b) to be offshore indicator species, including *Bairdia grahamensis, Orthobairdia oklahomensis, Bairdiacypris hoxbarensis, Coryellina* and the heavily ornamented Kirkbyidae. The Talpa faunas lack or contain very few shallow, euryhaline indicator groups, such as the Paraparchitacea, Kloedenellacea and the Hollinacea. Ameron et al. (1970) noted the Kirkbyidae and Bairdiidae were most typical of the biostrome and productoid/lamellibranch facies in the Upper Carboniferous (Sama Formation) of Spain. It should be noted that Ameron et al. (1970) do not refer to "biostrome" in the same sense that many American workers do, i.e., a carbonate buildup of organic origin. They are really referring to carbonate-rich clastics with maximum diversity faunas. The diversity of the ostracod fauna (14 species/327 specimens) compares well with other nearshore ostracod assemblages (Kaesler and Denver, 1988), and is more diverse than most mentioned by Ameron et al. (1970). The lack of nearshore indicator species suggests another factor limiting their diversity than simple salinity variations. Toomey et al. (1977) noted phylloid algal buildups tend to be relatively low diversity, and if the interpretation of the Flechado as a community with marine algae (not phylloid algae!) is correct, this may have been a factor in reducing diversity. This suggests the Flechado was a normal marine environment without great fluctuations in salinity, with a relatively low diversity ostracod assemblage.

The "microfauna" was dominated by infaunal deposit feeders (holothurians, ?ophiuroids) and epifaunal filter feeders (crinoids, echinoids). Among the ostracods, both swimming/crawling types and burrowing forms are found. The relatively large number of attached forms (i.e., foraminiferans, spirorbid worms) lacking obvious attachment sites suggests the possible presence of marine algae.

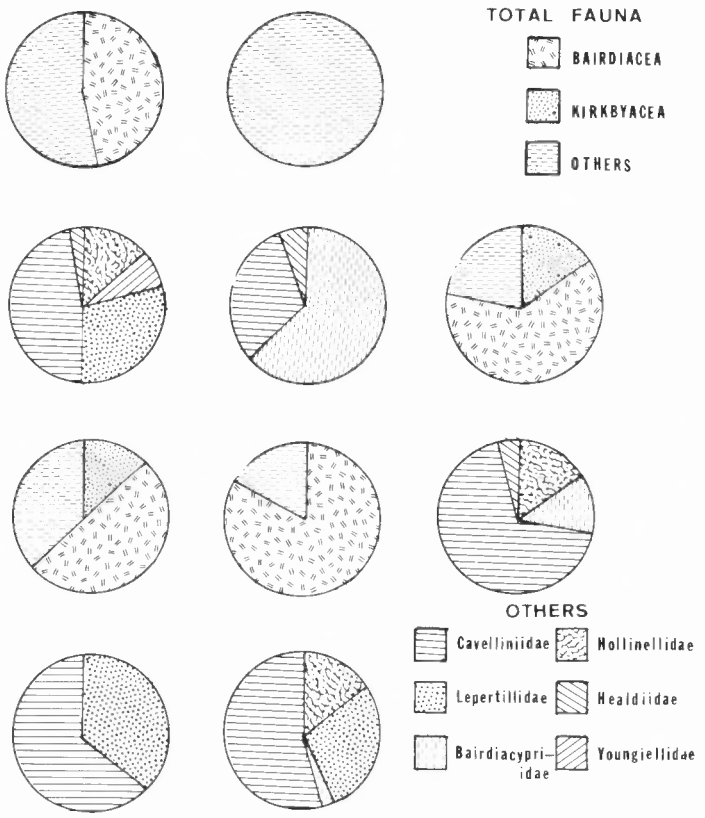


FIGURE 10. Percentages of ostracod groups from various Talpa ostracod faunas. Upper circle shows distribution of major groups in the total ostracod fauna from each sample and the lower circle shows the percentages of the "other" ostracods occupied by various families.

BIOSTRATIGRAPHY

The microfauna of the Flechado Formation contains many long-ranging species of little biostratigraphic importance. Also, many groups are too poorly documented to be reliable biostratigraphic markers. The most useful group for biostratigraphic studies found in this study are the Ostracoda, which are consistent with a Pennsylvanian, Desmoinesian age for the Flechado Formation at Talpa (Table 2) as previously established based on megafossil evidence. Most Flechado Ostracoda are long ranging, but few range below the Desmoinesian. Further restriction of age is based primarily on *Kirkbya fuldaensis,* which is easily

TABLE 2. Age distribution of the Flechado Formation Ostracoda. M = Morrowan, A = Atokan, D = Desmoinesian, Mi = Missourian, V = Virgilian.

Ostracod Taxon	Pennsylvanian Range				
	M	A	D	Mi	V
Kirkbya inornata		X			
kirkbya fuldaensis	X	X	X		
Amphissites centronotus	X	X	X	X	X
Roundyella simplicissimus			X	X	X
Coryellina capax			X		
Bairdia grahamensis			X	X	X
Orthobairdia oklahomensis			X	X	X
Bairdiacypris hoxbarensis			X	X	X
Pseudobythocypris pediformis		X	X	X	X
Silenites lenticularis			X		
Cavellina rotunda	?		X	X	X
Sulcella sulcata		X	X	X	X

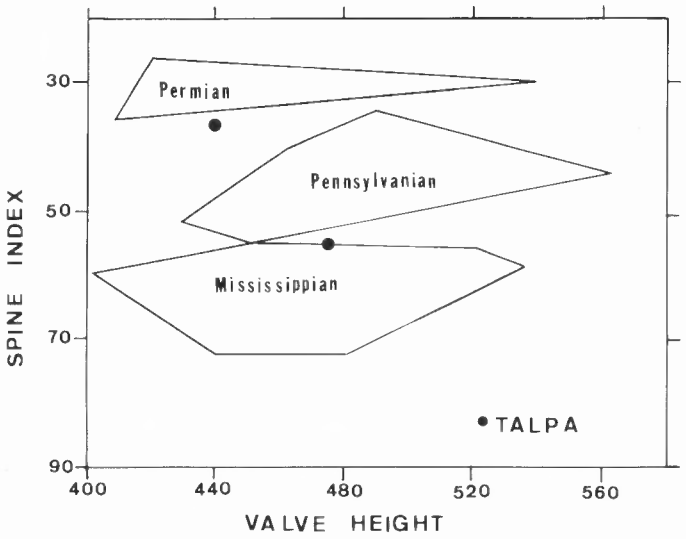


FIGURE 11. Plot of spine index versus valve height for the genus *Coryellina* (data from Sohn, 1962). Dots mark locations for two SEM measured specimens from the Talpa locality.

identified and does not range above the Desmoinesian. One important biostratigraphic marker in the Flechado Formation is the ostracod *Coryellina*. Sohn (1962) showed the posterior spine of this genus migrated from near the ventral margin in Mississippian species to near the dorsal margin in Permian species. Sohn quantified this relationship by plotting the height of the valves against the "spine index" (height from the dorsal margin to spine/total valve height × 100). The Flechado species plots of this genus were variable, plotting at the upper side of the Mississippian field and near the base of the Permian field (Fig. 11). Either the orientation using SEM photos was not well enough controlled, or variation of the Flechado material is greater than the Sohn model would suggest. A larger sample would probably produce better results. The ostracod fauna indicates a Pennsylvanian, Desmoinesian age for the Flechado. This would suggest the Flechado Formation at Talpa is in the upper part of the formation as indicated by Miller et al. (1963) based on fusulinid evidence.

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REFERENCES

Ameron, H. W. J., van, Bless, M. S. M. and Winkler Prins, C. F., 1970, Some paleontological and stratigraphical aspects of the Upper Carboniferous Sama Formation (Asturias, Spain): Mededelingen Rijks Geologische Dienst, nieuwe series, no. 21, 78 pp.

Bensen, R. H. and 16 others, 1961, Treatise on Invertebrate Paleontology, Part Q, Arthropoda 3, Crustacea, Ostracoda: Lawrence, Geological Society of America and University of Kansas Press, 442 pp.

Branson, C. C., 1937, Stratigraphy and fauna of the Sacajawea Formation, Mississippian, of Wyoming: Journal of Paleontology, v. 11, pp. 650–660.

Casey, J. M., 1980, Depositional systems and basin evolution of the late Paleozoic Taos trough, northern New Mexico [Ph.D. dissertation]: Austin, University of Texas, 253 pp.

Clarke, J. M., 1921, Organic dependence and disease: New York State Museum, Bulletin 221–222, 113 pp.

Clifton, R. L., 1942, Invertebrate faunas from the Blaine and Dog Creek Formations of the Permian Leonard Series: Journal of Paleontology, v. 16, pp. 685–699.

Cooper, C. L., 1946, Pennsylvanian ostracodes of Illinois: Illinois Geological Survey, Bulletin 70, 126 pp.

Durham, J. W., 1966, Ecology and paleoecology; *in* Moore, R. C., ed., Treatise on invertebrate paleontology, Part U, Echinodermata 3, 257 pp.

Elias, M. K., 1957, Late Mississippian fauna from the Redoak Hollow Formation of Southern Oklahoma, Part I: Journal of Paleontology, v. 31, pp. 370–427.

Frizzell, D. L. and Exline, H., 1956, Monograph of fossil holothurian sclerites: Bulletin, University of Missouri, School of Mines and Metallurgy, Technical Series, no. 89, 199 pp.

Geis, H. L., 1936, Recent and fossil pedicellariae: Journal of Paleontology, v. 10, pp. 427–448.

Gotz, G., 1931, Bau und Biologie Fossiler Serpuliden: Neues Jahrbuch Mineralogie B, Beilage Band 66B, pp. 385–438.

Haack, R. V. and Kaesler, R. L., 1980, Upper Carboniferous ostracode assemblages from a mixed carbonate-terrigenous-mud environment: Lethaia, v. 13, pp. 147–156.

Hampton, J. S., 1959, Statistical analysis of holothurian sclerites: Micropaleontology, v. 5, pp. 335–349.

Harper, J. A. and Morris, R. W., 1978, A new encrinasterid ophiuroid from the Conemaugh Group (Pennsylvanian) of western Pennsylvania, and revision of the Encrinasteridae: Journal of Paleontology, v. 52, pp. 155–163.

Hattin, D., 1959, An occurrence of *Opiuraster burrisi* Miller: Journal of Paleontology, v. 33, pp. 1125–1126.

Hess, H., von, 1962, Mikropaläontologische Untersuchungen an Ophiuren: Ecologae Geologicae Helvetiae, v. 55, pp. 595–656.

Hess, H., von, 1963, Mikropaläontologische Untersuchungen an Ophiuren. III. Die Ophiuren aus dem Callovien-Ton von Liesberg: Ecologae Geologicae Helvetiae, v. 56, pp. 1141–1164.

Jean, J. St., Jr., 1957, A middle Pennsylvanian foraminiferal fauna from Dubois County, Indiana: Indiana Geological Survey, Bulletin, no. 10, 66 pp.

Kaesler, R. L. and Denver, L. E., 1988, Distribution and diversity of nearshore ostracoda: Environmental control in the Early Permian; *in* Hanai, T., Ikeya, N. and Ishizaki, K., eds., Evolutionary biology of the Ostracoda, its fundamentals and applications, pp. 671–683.

Kelley, V. C. and Northrop, S. A., 1975, Geology of the Sandia Mountains and vicinity, New Mexico; New Mexico Bureau of Mines & Mineral Resources, Memoir 29, 136 pp.

Kietzke, K. K., 1983, Ostracods from the Atrasado and Red Tanks Members, Madera Formation (Upper Pennsylvanian–Lower Permian), of central New Mexico: New Mexico Journal of Science, v. 23, pp. 17–18.

Kietzke, K. K., 1989, Calcareous microfossils from the Triassic of the southwestern United States; *in* Lucas, S. G. and Hunt, A. P., eds., Dawn of the age of dinosaurs in the American Southwest: Albuquerque, New Mexico Museum of Natural History, pp. 223–232.

Kues, B. S., 1984, Pennsylvanian stratigraphy and paleontology of the Taos area, north-central New Mexico: New Mexico Geological Society, Guidebook 35, pp. 107–114.

Lane, B. O., 1962, The fauna of the Ely Group in the Illipah area of Nevada: Journal of Paleontology, v. 36, pp. 888–911.

Lane, N. G., 1964, Paleoecology of the Council Grove Group (Lower Permian) in Kansas, based on microfossil assemblages: Kansas Geological Survey, Bulletin 170, 23 pp.

Loeblich, A. R., Jr. and Tappan, H., 1988, Foraminiferal genera and their classification, vols. 1 and 2: New York, Van Reinhold Company, 970 pp.

Mayou, T. V., 1969, A new species of Permian ophiuroid from Nevada: Journal of Paleontology, v. 43, pp. 936–940.

Melnyk, D. H. and Maddocks, R. F., 1988a, Ostracode biostratigraphy of the Permo-Carboniferous of central and north-central Texas, part I: paleoenvironmental framework: Micropaleontology, v. 34, 20 pp.

Melnyk, D. H. and Maddocks, R. F., 1988b, Ostracode biostratigraphy of the Permo-Carboniferous of central and north-central Texas, part II: ostracode zonation: Micropaleontology, v. 34, 40 pp.

Miller, H. W., Jr., 1958, A new genus and species of Permian ophiuroid from Kansas: Journal of Paleontology, v. 32, pp. 357–361.

Miller, J. P., Montgomery, A. and Sutherland, P. K., 1963, Geology of part of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 11, 106 pp.

Morris, R. W., Rollins, H. B. and Shaak, G. D., 1973, A new ophiuroid from the Brush Creek Shale (Conemaugh Group, Pennsylvanian) of western Pennsylvania: Journal of Paleontology, v. 47, pp. 473–478.

Pabian, R. K. and Strimple, H. L., 1973, A Pennsylvanian ophiuroid from

southwestern Iowa: Iowa Academy of Science Proceedings, v. 80, pp. 39–40.

Pawson, 1966, Phylogeny and evolution of holothuroids; *in* Moore, R. C., ed., Treatise on invertebrate paleontology, part U, Echinodermata 3: Lawrence, Geological Society of America and University of Kansas Press, pp. 641–646.

Peterson, R. M. and Kaesler, R. L., 1980, Distribution and diversity of ostracode assemblages from the Hamlin Shale and Americus Limestone (Permian-Wolfcampian) in northeast Kansas: University of Kansas Paleontological Contributions, Paper 100, 26 pp.

Plas, L. P., Jr., 1972, Upper Wolfcampian(?) Mollusca from the Arrow Canyon Range, Clark County, Nevada: Journal of Paleontology, v. 46, pp. 249–260.

Reese, E. S, 1966, The complex behavior of echinoderms; *in* Boolootian, R. A., ed., Physiology of Echinodermata: New York, Interscience Publications, pp. 157–218.

Shaver, R. H., 1958, A study of *Pseudobythocypris pediformis,* a new name for an old ostracod: American Midland Naturalist, v. 59, pp. 120–137.

Shaver, R. H. and Smith, S. G., 1974, Some Pennsylvanian Kirkbyacean ostracods of Indiana and Midcontinent series terminology: Indiana Geological Survey, Report of Progress 31, 59 pp.

Sohn, I. G., 1960, Paleozoic species of *Bairdia* and related genera: U.S. Geological Survey, Professional Paper 330-A, 105 pp.

Sohn, I. G., 1961, *Aechminella, Amphissites, Kirkbyella,* and related genera: U.S. Geological Survey, Professional Paper 330-B, 160 pp.

Sohn, I. G., 1962, Stratigraphic significance of the Paleozoic genus *Coryellina* Bradfield, 1935: Journal of Paleontology, v. 36, pp. 1201–1213.

Sohn, I. G., 1972, Late Paleozoic ostracode species from the conterminous United States, a revision of the Paraparchitacea: U.S. Geological Survey, Professional Paper 711-B, 13 pp.

Spencer, W. K. and Wright, C. W., 1966, Asterozoans; *in* Moore, R. C., ed., Treatise on invertebrate paleontology, part U, Echinodermata 3: Lawrence, Geological Society of America and University of Kansas Press, pp. 4–107.

Spreng, A. C. and Howe, W. B., 1963, Echinoid jaws from the Mississippian and Pennsylvanian of Missouri: Journal of Paleontology, v. 37, pp. 931–938.

Sutherland, P. K. and Harlow, F. H., 1973, Pennsylvanian brachiopods and biostratigraphy in southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 27, 173 pp.

Toomey, D. F., 1980, History of a Late Carboniferous phylloid algal bank complex in northeastern New Mexico: Lethaia, v. 13, pp. 249–267.

Toomey, D. F., Wilson, J. L. and Rezak, R., 1977, Evolution of Yucca mound complex, late Pennsylvanian phylloid-algal buildup, Sacramento Mountains, New Mexico: American Association of Petroleum Geologists Bulletin, v. 12, pp. 2115–2133.

Tway, L. E., 1979, A coded system for utilizing ichthyoliths of any age: Micropaleontology, vol. 25, pp. 151–159.

Tway, L. E. and Zidek, J., 1982, Catalogue of Late Pennsylvanian ichthyoliths, part I: Journal of Vertebrate Paleontology, v. 2, pp. 328–361.

Tway, L. E and Zidek, J., 1983, Catalogue of Late Pennsylvanian ichthyoliths, part II: Journal of Vertebrate Paleontology, v. 2, pp. 414–438.

Webster, G. D. and Lane, N. G., 1970, Carboniferous echinoderms from the southwestern United States: Journal of Paleontology, v. 44, pp. 276–296.

Weller, J. M., 1930, Ophiuroid remains of Pennsylvanian age: Journal of Paleontology, v. 4, pp. 1–13.

Wenlund, R. J., 1977, Biostratigraphy and paleoecology of holothurian sclerites from the Pinery Member, Bell Canyon Formation (Permian) of the Delaware Basin of West Texas [M.S. thesis]: Austin, University of Texas.

Werrell, W. L., 1961, Pennsylvanian ostracods and fusulinids of Tijeras and Cedro Canyons, Bernalillo County, New Mexico [M.S. thesis]: Albuquerque, University of New Mexico, 78 pp.

Xiu-gao, Z. and Jin-hua, L., 1987, Systematic position of *Silenites* Coryell and Booth, 1933 (Ostracoda): Acta Micropalaeontologica Sinica, v. 4, pp. 403–408.

Yancy, T. E. and Stevens, C. H., 1981, Early Permian fossil communities in northeastern Nevada and northwestern Utah; *in* Gray, J., Boucot, J. A. and Berry, W. B. N., eds., Communities of the past: Stroudsburg, Dowden, Hutchinson, and Ross, pp. 243–270.

Zeller, E. J., 1950, Stratigraphic significance of Mississippian endothyroid Foraminifera: University of Kansas Paleontological Contribution, Protozoa, Art. 4, pp. 1–23.